SCIENCE 7

MODULE 6:
EVIDENCE OF EROSION

Distance Learning

Alberta
EDUCATION

Science 7

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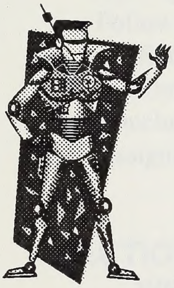
ACKNOWLEDGEMENTS

This module has been based on **Science Directions 7** by John Wiley & Sons/Arnold Publishing Ltd., 1989. Program consultant was Douglas A. Roberts. The author team for the complete text included Wilson C. Durward, Eric S. Grace, Gene Krupa, Mary Krupa, Alan J. Hirsch, David A.E. Spalding, Bradley J. Baker, and Sandy M. Wohl. Contributing author was Jean Bullard. Portions of **Science Directions 7** have been used throughout the Module Booklet and have been adapted in a variety of ways.

Cover photographs courtesy of Dave Mussell, Edmonton.

Title page photographs for Sections 2, 3 and 5 courtesy of Bernie Galbraith, Edmonton.

Science 7
Student Module
Module 6
Evidence of Erosion
Alberta Distance Learning Centre
ISBN No. 0-7741-0410-4



Welcome to Module 6!

We hope you'll enjoy your study of Evidence of Erosion.

To make your learning a bit easier, a teacher will help guide you through the material.

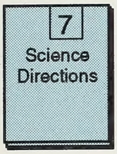
So whenever you see this icon,

turn on your audiocassette and listen.

Contents

OVERVIEW

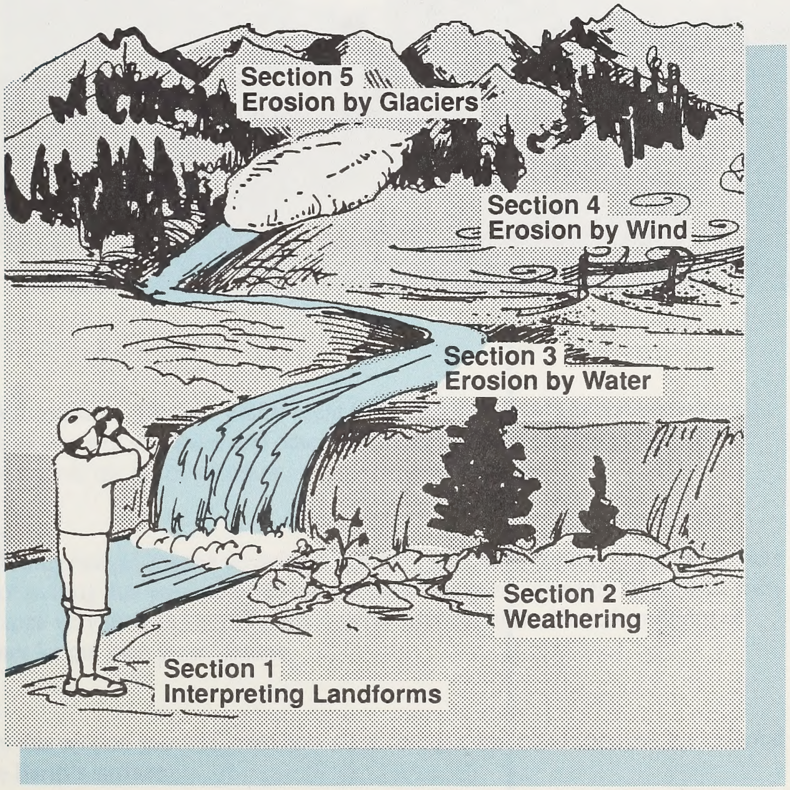
At one time thick sheets of ice covered most of Alberta. Now glaciers are found only on some mountains. Surfaces of mountains are constantly being worn down. Water rushing over waterfalls wears away the rock underneath. Wind can blow away dirt that is capable of growing plants. Mountains, hills, plains, and other landforms are not as stable as they seem. Changes do occur on the Earth's surface.



Read page 296 and examine the photographs on page 297 of *Science Directions 7*. The information on these pages provides a good introduction to what you will be studying in Module 6.

In this module you will learn how science explains the changes on the Earth's surface. You will find out how even the hardest rocks are slowly broken into smaller pieces and how these pieces are moved by wind, water, and ice. You will learn how to make inferences about how the landscape has changed.

Evidence of Erosion



Evaluation

Your mark in this module will be determined by your work in the Assignment Booklet. You must complete all assignments. In this module you are expected to complete four section assignments.

The assignment breakdown is as follows:

Section 2 Assignment	**34%**
Section 3 Assignment	**21%**
Section 4 Assignment	**20%**
Section 5 Assignment	**25%**
TOTAL	**100%**

Note: There is no assignment for Section 1.

Section

1

Interpreting Landforms

WESTFILE INC.

Mountains, hills, and plains seem to be stable elements in our environment, but as you will see, these and other landforms are not as stable as they seem. Changes to the Earth's surface are constantly occurring.

Some changes happen so quickly that they are called natural disasters. Others take so long that you hardly know that there has been a change. The Earth will change very little in your lifetime, but the lifetime of the Earth is millions of times longer than your lifetime.

In this section you will learn how slow changes and rapid changes have altered the Earth's surface.

Activity 1: Recognizing Change

Imagine that you made a large pile of sand and soil in a field and left it for a month. What evidence would you look for that would make you think that it had rained since you made the pile?

Observation: information gathered by using the five senses

Inference: an explanation based on observations; a conclusion

Deep grooves or gullies would be one **observation** to support the **inference** that rain had fallen on the pile.

This is a very simple example, but it is useful to illustrate how scientists try to explain the changes that have taken place on the Earth's surface. Since most changes to the Earth's surface occur so slowly, scientists must infer what happened thousands and millions of years ago. Scientists start by observing, then make inferences to explain their observation. Put another way, scientists read the signs on Earth's **landforms**, and interpret their meaning.

Landforms: the natural physical features of the land

Geologist: a scientist who studies the Earth

A scientist who studies the Earth is called a **geologist**. By studying the Earth's surface and by observing ongoing changes, geologists gather evidence that helps make sense of what we see.

What types of observations might provide useful evidence to a geologist? What would a geologist look for – what would you look for – to help you figure out changes that are taking place on the Earth's surface?

To get started, here are three examples of observations, and the inferences for each that were made by scientists.

Example A

Observations:

Small rocks and boulders are found in and on the soil of farms in Alberta. Close observation shows that these rocks and boulders are identical to the types of rocks found in the mountains.

Questions:

Were these rocks and boulders formed in the fields? Why are the rocks in the field the same as rocks in the mountains?

Inferences:

Since the boulders on the farms are the same type of rock found in the mountains, a possible explanation is that the boulders were formed in the mountains and were then moved to the farms by some force. This is an example of an inference. Scientists infer explanations of what they see based on the best evidence available.

Inferences such as these seem obvious once they are developed. However, you should note that scientists sometimes change their explanations about formations they have studied. Inferences that are accepted today may be modified or even completely changed as new observations and new interpretations are made. All of the explanations in this module have been developed through years of study and interpretation. If they appear obvious and simple to you, it is because they are good explanations.

Example B

Observations:

If you go to a river bank and pick up some stones, you will see that most of them are rounded, not jagged. Also, you will notice that the stones are a variety of colours and textures.

Questions:

Were the rocks formed on the river bank? Why do they have smooth, rounded surfaces?

Inferences:

Geologists look for simple explanations. It seems unlikely that so many different types of rocks would be formed next to each other and that they would have smooth round shapes, so different from the rocks around them. A suitable inference might be that the rocks were not formed on the river bank and that they were moved and shaped by some force.

Example C

Observations:

For the last in this series of examples, imagine that you are outside just after a heavy rainstorm. When you look closely at the water running into ditches or down streets, you notice that it is brown with mud.

Questions:

Where did the mud come from? Do the fields and gardens that the water is running from show evidence of soil loss?

Inferences:

A most likely inference is that the rainwater is carrying small particles of rocks, sand, and dirt from the fields and gardens. What you are seeing is evidence of a change, a change that you can then examine more closely.

Scientists start with questions and observations. Deciding what questions to ask and what observations to make are both important. Good explanations are based on these first steps, and they require a lot of careful thought.

Next you will examine three photographs in your textbook. For each photograph you should

- describe your observations
- infer the changes you think have occurred
- explain what you think caused the change

7 Science Directions

1. Examine the photograph on the bottom left corner on page 297 of *Science Directions 7*. It shows a lady standing beside a hoodoo.

   a. Observations (Describe the appearance of a hoodoo.)

   ____
   ____
   ____
   ____

   b. Inferences and Explanations (How do you think this formation was formed?)

   ____
   ____
   ____
   ____

7 Science Directions

2. Examine the photograph on the top right corner of page 297 of *Science Directions 7*. It shows a waterfall.

   a. Observations (Describe what you observe about where the water flows and what is around it.)

   ____
   ____
   ____
   ____

   b. Inferences and Explanations

   ____
   ____
   ____
   ____

3. Examine Photograph B on page 299 of *Science Directions 7*. It shows an avalanche.

   a. Observations (What is happening in this picture?)

   ____

   ____

   ____

   ____

   b. Inference and Explanations (What do you think makes this happen?)

   ____

   ____

   ____

   ____

Check your answers with your learning facilitator.

Activity 2: Sudden and Slow Changes

In this activity refer to the appropriate pages of *Science Directions 7* when reference to your textbook is made.

On April 29, 1903 most of the citizens of Frank, Alberta were sleeping when a sudden change occurred. Read page 298 of your textbook about how the Frank Landslide has changed the whole side of Turtle Mountain, the adjoining valley, and the townsite of Frank.

Photograph B on page 299 of the textbook shows that rocks are not the only things that fall off mountains. Where deep snow builds up, there is danger of snowslides. Falls or slides of snow, ice, rocks, dirt, and mud down mountainsides are called **avalanches**.

Avalanche: a large mass of snow and ice, or of dirt and rocks, sliding or falling down a mountainside

Structures called snowsheds have been constructed across the rail lines and roads where avalanches occur most frequently. Photograph A on page 299 of the textbook shows snowsheds. If you travel through the Rogers Pass in British Columbia, watch for snowsheds, and look up the mountain to see the paths of avalanches.

Sudden changes that you have looked at so far are easy to explain. You can watch them happen. However, most changes to the surface of the Earth take place much more slowly. Many of the slow changes are not easy to notice even during the course of one's lifetime. How, then, can any person know that such change has taken place? To find out, read the information and see the photographs on pages 301 and 302 of the textbook.

Talus: an accumulation of irregular shaped rocks at the base of a cliff or steep mountain

In your textbook reading you were asked to look at the slope just under the mountain shown in the photograph on page 301. This slope is called a **talus**. Were you able to determine how long it took the talus to form? Did it form quickly or did it happen over a long period of time?

Some of the changes you read about may seem insignificant because their effects on the Earth's surface are so small. In their lifetime, few people see the changes in a river or a change in the height of a mountain. To understand the forces that cause these changes, it is important to realize how much time has elapsed during the Earth's history. For example, assume that a stream is eroding the rocks underneath it at a rate of 0.1 mm per year. This is about the thickness of a human hair. In 10 000 years, the stream will have worn downward 1 000 mm or 1 metre. You would never notice the 0.1 mm in one year or the 7 mm that would be eroded away in an average lifetime, but over a much longer period of time the changes are quite significant.

In 100 seconds Turtle Mountain lost about 170 m of its height! If it had eroded at a rate of 0.1 mm/year it would have taken 1 700 000 years to produce the same effect!

You have seen that there are changes that occur suddenly and other changes that occur very slowly. Yet some changes can be observed by anyone who visits the same place regularly over a period of time. The following case will help you understand this better.

Last year, while in grade seven, Joanne attended a newly built junior high school. For a project she was asked to observe and record any changes taking place around the school during the year.

Turn to page 300 of *Science Directions 7* and read JOANNE'S REPORT. Then answer the following questions.

1. Joanne wanted to explain what she saw and tell why it happened. What did she see that she wanted to explain?

____

____

____

2. How did she explain what she saw? Write two inferences (explanations) that Joanne made.

   - inference one – Joanne thought that ______________________

     ____

     ____

   - inference two – Joanne thought that ______________________

     ____

     ____

3. What did Joanne observe that supports these inferences?

   - inference one – ____

     ____

     ____

   - inference two – ____

     ____

     ____

4. What might happen if the paths are used for many years without being paved?

____

____

____

5. List two examples of other small and slow changes that can change the shape of the land. If you can, think of examples from around where you live.

 • ______________________________

 ____

 • ______________________________

 ____

6. Name or describe two examples of sudden changes that affect the shape of the land.

 • ______________________________

 ____

 • ______________________________

 ____

Check your answers with your learning facilitator.

Follow-up Activities

If you had difficulties understanding the concepts in the activities, it is recommended that you do the Extra Help. If you have a clear understanding of the concepts, it is recommended that you do the Enrichment.

Extra Help

The Earth seems quiet and unchanging. You rarely notice any change on it. Yet when you listen to the news, you hear that the Earth is not so quiet and unchanging. Earthquakes and volcanoes strike and change the land. Avalanches can close roads for several days. Floods cause people to abandon their homes. Many other changes occur so slowly that in a lifetime you may not notice any change. Slow changes, through constant action over long periods of time, have caused major changes to the landscape. But imagining time periods of thousands and millions of years is difficult.

You may choose to do only Part A, or Part B,
but you may do both Part A and Part B if you wish.

Part A involves reading descriptions about changes that occurred in various parts of the world, then explaining whether you think the change was sudden or slow.

Part B involves observing areas in your neighbourhood for evidence of change, then classifying the changes observed as sudden or slow.

Part A

1. Read the descriptions of the following changes. Decide if the change is sudden or slow. Then give an explanation for your answer. The first one has been done for you as an example.

   a. In 1906 an earthquake destroyed San Francisco, California. The shock was so violent that many people who were standing were thrown to the ground, and many people who were sleeping were thrown from their beds. The tremor was felt from Coos Bay, Oregon, to Los Angeles, California, a distance of about 1 100 km.

   Type of Change (sudden or slow): *sudden* ____________________

   Explanation:

   The movements described are powerful ones that occurr over a short period of time. Earthquakes are usually over in a matter of minutes.

   b. In the year 79 AD, Mount Vesuvius, in Italy, erupted and covered Pompeii with more than 7 m of ash and lava. More than 2 000 people perished. People had been living near Mount Vesuvius for over 800 years. There is no record of a previous eruption.

   Type of Change (sudden or slow): ____________________

   Explanation:

   ____

   ____

   ____

c. Records of Niagara Falls, kept since it was first described in 1678, show that the crest of the Canadian part of the falls has receded about 50 m every 100 years.

Type of Change (sudden or slow): ______________________

Explanation:

____

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d. The volcano Surtsey began to erupt in the ocean off the southwest coast of Iceland on November 14, 1963. Two years later, Surtsey was an island over 2 km^2 in area and 150 m high, with plants growing on it.

Type of Change (sudden or slow): ______________________

Explanation:

____

____

____

e. The North Saskatchewan River winds through Edmonton, Alberta, in a deep wide valley. Bridges built years ago are still serviceable since the river's course has not changed greatly since the bridges were built.

Type of Change (sudden or slow): ______________________

Explanation:

____

____

____

f. The island of Hawaii consists of five great volcanoes grown together. They rise from the ocean floor to a height of more than 4 000 m above sea level. Two of the volcanoes, Mauna Loa and Mount Kilauea, still erupt occasionally.

Type of Change (sudden or slow): ______________________

Explanation:

____

____

____

Check your answers with your learning facilitator.

Part B

2. Observe change in your neighbourhood. Look for three areas near your home that you can visit easily. You may select part of a garden, a grassy area on a slope, an area of earth beside a wall, a river bank, or any other areas where you think changes might occur.

   Watch for evidence of slow change and evidence of sudden change. Record your observations carefully at each location. Then classify the type of change as one of the following: no change, slow change, or sudden change.

   Give reasons for your classification.

a. Neighbourhood Area One

Observations:

Type of Change ______________________________

Explanation:

b. Neighbourhood Area Two

Observations:

Type of Change ______________________________

Explanation:

c. Neighbourhood Area Three

Observations:

Type of Change ______________________________

Explanation:

Discuss your answers with your learning facilitator.

Enrichment

When you look at mountains, hills, and valleys, you may wonder how they were formed. Possibly you have wondered if a river has always been where you see it now.

Scientists start to answer questions like these by observing the landforms. The next step is to look for patterns that can lead to inferences and explanations of how things might have happened. Good explanations should be as simple as possible and take into account all of the available evidence. If the explanation does not account for some of the evidence, the explanation may be modified, or rejected. Scientists are always looking for more observations to support or modify their ideas.

1. Read the following descriptions. Each description is followed by two possible inferences that explain the observations. Choose the better inference. Then briefly describe why you think it is better. Describe one additional observation you would like to make to support, modify, or reject the inference you chose.

   a. A 75-year-old building has steps made out of slate, which is a type of rock. The steps are worn down in the centre but show very little wear on their outer sides.

      Inference A: The material near the centre of the steps is softer than the material near the outside. This is why the steps wear down faster near the centre.

      Inference B: More people walk on the centre of the steps than on the outside. This is why the steps wear down faster near the centre.

      The more likely inference is ______________________________.

      Explanation:

      ____

      ____

      ____

      ____

      Additional observations or tests you would like to make to check your inference:

      ____

      ____

      ____

      ____

      ____

      ____

b. The large valley located between Banff and Lake Louise has a fairly small river running in it.

Inference A: The river was once much larger. This is why the valley is so big compared to the river.

Inference B: The glacier at Lake Louise was once much larger and filled the wide valley. This is why the valley is so big compared to the river.

The more likely inference is ______________________________.

Explanation:

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Additional observations or tests you would like to make to check your inference:

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c. A paved bicycle path has several dandelions growing through it. There are lots of dandelions growing near the edge of the path. The path is three years old.

Inference A: When the path was paved, there were spots missed. The dandelions grew in these missed spots.

Inference B: The dandelions grew through the path by forcing up and cracking the path. This is why a few are now growing through the path.

The more likely inference is ______________________________.

Explanation:

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Additional observations or tests you would like to make to check your inference:

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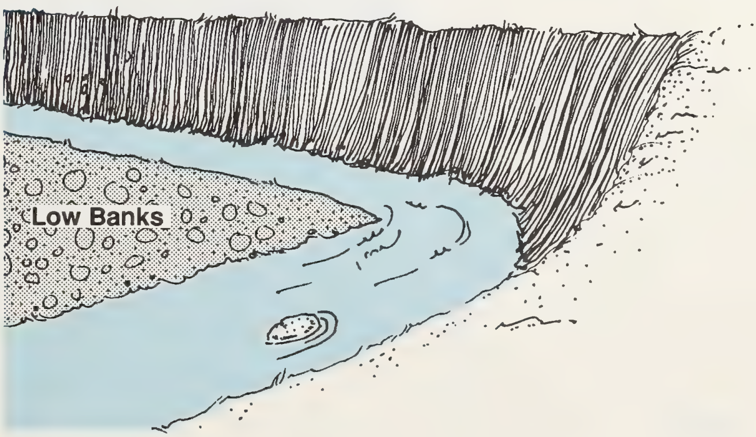
d. The bank on the inside of a bend in a river is about 5 m above the river, then drops to an area that is fairly low and flat. On the outside of the bend, the bank is quite steep and is 5 m above the river. Where the river runs straight, the banks on both sides are about the same distance from the river.



Inference A: The river flows faster on the outside of a bend than on the inside of a bend. The faster running water on the outside of the bend cuts away at the bank more than on the inside of the bend.

Inference B: The bank on the inside of the bend is softer than the bank on the outside of the bend. The bank on the inside of the bend is more easily carried downstream by the river.

The more likely inference is ______________________.

Explanation:

____

____

____

____

Additional observations you would like to make to check your inference:

____

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Check your answers with your learning facilitator.

Conclusion

Even though you see very few day-to-day changes in the Earth's surface, the effect of enormous lengths of time make even very slow changes very important.

Some evidence of these changes are smooth rocks in rivers, changing courses of rivers, avalanches, earthquakes, volcanoes, waterfalls, and talus slopes.

Scientists explain these changes by making inferences from observations. Scientists look for further observations to support, change, or reject their interpretations. The rest of this module will help you understand some of these interpretations.

Assignment Booklet

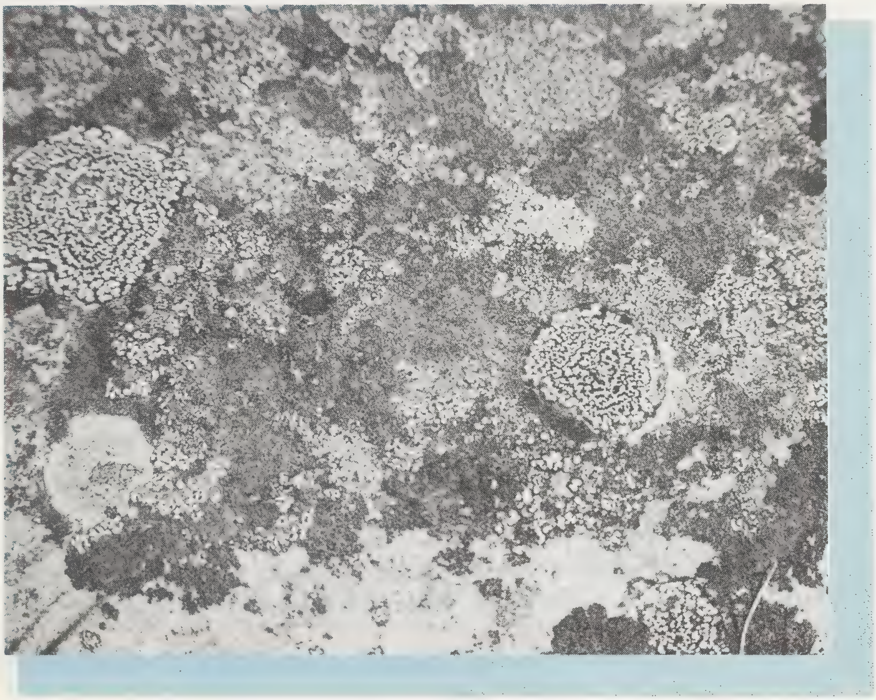
ASSIGNMENT

There is no assignment for Section 1. Proceed to Section 2.

Section

2

Weathering



In Section 1, you learned that scientists use observations as evidence when trying to explain the sudden and slow changes that occur on the Earth's surface.

Part of the explanation for these changes involves the idea of weathering. Weathering is one of the ways in which rocks that make up the mountains and the bases of continents are broken down into tiny grains of sand and soil. The photograph shows one type of weathering caused by lichens growing on rocks.

In this section, you will learn how scientists develop explanations about the weathering of rock. You will learn about different variables that affect how fast something weathers. By the end of the section you should be able to recognize and describe examples of mechanical, biological, and chemical weathering.

Activity 1: Mechanical Weathering

Evidence of Weathering

From a distance, mountains appear to be solid rock. As you get closer, you find that the mountain surfaces have lots of cracks and loose rocks are piled up at the bases of the mountains. Sometimes springs of water trickle from holes in the sides of mountains. These trickles of water join to become streams and rivers which carry loose sand, silt, and small pebbles away from the mountain. Something must be slowly breaking these small pieces of rock from the mountain.

Think about these additional changes that occur away from mountains. Bumps and holes often form in paved roads. Concrete sidewalks often develop cracks and chips. Paint on buildings sometimes changes colour and sometimes cracks, forming flakes. An unpainted piece of iron rusts if left outside too long. You have most likely noticed that some old wooden fences and buildings turn a grey colour as they get older. Something causes these changes.

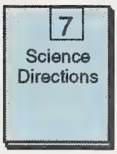
Weathering: the natural breaking down of solid materials into smaller pieces, and the changes in colour that take place on solid materials

Scientists use the term **weathering** to describe changes such as these. Each of these changes involves the natural breaking down of solid materials into smaller pieces. Sometimes the changes show up first as a change in colour or appearance, sometimes by pieces that crack and come loose from the main material that is being weathered.

Weathering may take place in several different ways. Three types of weathering are

- mechanical weathering
- chemical weathering
- biological weathering

Section 2 will help you understand what is involved in each of the three kinds of weathering. Mechanical weathering will be discussed in this activity.



For an introduction to mechanical weathering, read page 303 of *Science Directions 7*.

Mechanical weathering: the weathering caused by changes in temperature and by water freezing in cracks

Your textbook reading mentions that over a long period of time, repeated expansion and contraction causes rocks to crack. Also, in Module 4, you learned that different materials expand and contract different amounts. In a rock made of different minerals, changes in temperature over a long period of time may weaken and eventually break the rock. Formation of cracks in rocks is the first step in the process of **mechanical weathering**.

The next step in mechanical weathering happens when water gets into the cracks in the rock. When it becomes cold during the night or in the cold of Canadian winters, the water in these cracks will freeze. Water expands when it freezes. As temperatures drop below 0°C, the water in cracks freezes first at the surface, trapping the remaining water inside the cracks in the rock. This water, trapped inside these cracks, continues to freeze as the colder temperatures reach farther and farther into the rock. This trapped water expands as it freezes and pushes outward on the rock with tremendous force.

Over a long period of time, the freezing and thawing of the water in the cracks will break the rocks apart. This second step in the process of mechanical weathering is called **ice wedging**.

Ice wedging: *water getting into cracks in rock, freezing in the cracks, and breaking the rocks apart*

Scientists were able to develop this explanation for weathering because they had observed how changes of temperature affect materials, and they had observed that water expands when it freezes. Putting these observations together to explain rock breaking required curiosity and creative thinking.

People who do not want to empty their swimming pools for the winter sometimes put a log in the pool before the water freezes. The log is more easily compressed than are the concrete sides of the pool. As the water freezes, it breaks up the log instead of the sides of the pool. But unless you have personally observed the force exerted by water freezing in a confined space, it will seem unlikely to you that an everyday process such as the freezing and thawing of water could help to break down huge mountains. The following investigation will give you the opportunity to test for yourself the power of water as it freezes.

Follow these directions to observe the power of water as it freezes. Remember, water is unusual because it expands when it freezes. Most materials get smaller when they change from liquid to solid.

Materials You Need

- plastic bottle with screw top
- plastic bag
- water
- freezer

Steps to Follow

Step 1: Fill the plastic bottle as full as you can with water and screw the top on tightly. Carefully observe the bottle of water. Under Observations draw a diagram to show the appearance of the container at this stage.

Step 2: Place the bottle of water in a plastic bag and place the bottle and bag in a freezer. Leave it overnight to find out what happens as the water freezes.

Step 3: Take the container out of the freezer and look for changes. Handle the bag and container carefully! Under Observations draw and describe the changes you see.

Observations

In the following chart include drawings and descriptions of what you observed.

Before Freezing	After Freezing

This demonstration of what water does when it freezes should help you understand what could happen to rock. The plastic container represents rocks with cracks in them. Conditions in a freezer represent a cold night when water freezes.

Questions to Answer

1. How could this kind of change cause rocks to split apart? What would have to happen?

____

____

____

2. The container you used is much larger than many cracks in rocks. Explain why it would take a long time for water freezing and thawing in cracks to break rocks apart.

3. Why should you never store liquids in a glass bottle in a freezer?

4. Use what you have learned so far in this activity about the mechanical weathering of rocks to help you answer the following questions.

   a. What is the first sign that mechanical weathering is taking place in rocks?

   b. What causes this to happen?

   c. What further change takes place as mechanical weathering carries on?

   d. What causes this to happen?

5. Refer to question 4 when answering this question. Why do you think scientists need to include the first part of the explanation for weathering? (Can you explain this type of weathering by using only the second part of the explanation?)

Strata: parallel layers of rocks

6. Examine the top left photograph on page 302 of *Science Directions 7*. In Section 1, this photograph was used as an example of slow change. The photograph shows **strata** of rocks near Banff, Alberta.

   a. What evidence of weathering do you see in the rock strata?

   b. What additional evidence would you look for if you were able to visit the location?

Check your answers with your learning facilitator.

Activity 2: Chemical Weathering

Read the cartoon on pages 306 and 307 of *Science Directions 7*. It shows that tourists are not allowed to carry soft drinks into St. George's Chapel in England's Windsor Castle. The steps which have been in use for several centuries were being seriously damaged by the acids in the drinks spilled by visitors. If steps made of rocks can be damaged by the acid that you drink in soft drinks, could acids also weather rock in the natural environment? For example, what causes caves to form?

Caves are often formed by the underground flow of water. Castleguard Cave in Banff National Park is the longest cave so far discovered in Canada. An entrance to the cave was found in about 1920, but it was not explored until much later. Eighteen kilometres of tunnels had been explored by the mid-1980s. For an example of what a tunnel in limestone rock looks like, see the photographs at the bottom of page 306 in the textbook. In one of the photographs two structures, **stalactites** and **stalagmites**, are shown. These are often found in limestone caves. What causes them?

Stalactite: a spike-shaped formation of calcium carbonate hanging down from the roof of a cave

Stalagmite: a spike-shaped formation of calcium carbonate extending upward from the floor of a cave

Chemical weathering: the weathering or breaking down of rocks by the action of chemicals, resulting in different materials being formed

The idea of **chemical weathering** helps to explain these features. Mineral-rich water constantly drips from some cave ceilings forming spikes that hang from the roof, called stalactites, and spikes rising from the floor, called stalagmites.

To explain how these features occur, scientists study the water that is found in the caves. What they find is that the water in the caves contains a small amount of acid called carbonic acid. Where does this acid come from? Scientists have demonstrated that carbon dioxide in the air can combine with rainwater to form carbonic acid. This is the same acid that is in soft drinks. When you open a bottle of pop, you see bubbles form. The bubbles are the carbon dioxide that is leaving the soft drink and going back into the air.

Carbonic acid can dissolve calcium carbonate. Limestone and marble are two kinds of rock that contain large amounts of calcium carbonate. Scientists explain that in areas where there are limestone rocks on the Earth's surface, carbonic acid can dissolve the calcium carbonate in the limestone and form large holes in the rocks. Some of these holes form caves.

Underground holes and caves may connect up and become underground tunnels. A river may disappear down a hole in the rock, flow in an underground tunnel for a while, and then reappear on the surface of the ground, perhaps many kilometres from the place where it disappeared underground. If the water contains carbonic acid it will dissolve more calcium carbonate, making the tunnel larger. The drawing on page 306 with the caption, The case of the disappearing river, helps to illustrate this point.

This action of acid on rock is an example of chemical weathering. The chemicals, carbonic acid and calcium carbonate, act together to form a material that will dissolve in water. What you see is a hole where there was once solid rock. Another example of chemical weathering is the action of water on iron. The result of the chemical weathering of iron is rust. Rust is a different material than the iron from which it was formed. Chemical weathering involves the breaking down of material by the action of chemicals, which results in different materials being formed.

The following demonstration or description will help you understand chemical weathering better.

Do either Part A or Part B.

Part A involves using some common materials to observe two chemical changes.

Part B involves reading descriptions of two common chemical changes.

Part A

Note: You do not need to complete Part A if you wish to do Part B.

Chemical weathering involves changes that result in new materials. Use the following materials as described. Then answer the questions.

Materials You Need

- two uncoated iron nails
- glass of water
- two pieces of chalk
- bottle of soda pop

Steps to Follow

Step 1: Put one uncoated iron nail in a glass of water. Leave the other nail outside the glass of water.

Step 2: After 24 hours, compare the nails.

Interpretations

1. Describe the colour changes that occur on the nail.

____

2. Is the rust harder or softer than the iron nail?

____

3. What evidence is there that rust is a different material from iron?

____

____

4. Which is more easily broken into smaller pieces, the iron or the rust?

____

Steps to Follow (continued)

Step 3: Open the bottle of soda pop and put one piece of chalk in it. Leave the other piece of chalk outside the bottle of pop.

Step 4: After two hours, compare the two pieces of chalk.

Interpretations (continued)

5. a. Describe your observations.

____

____

b. Is this an example of mechanical or chemical weathering?

____

c. Give a reason for your answer.

____

____

Check your answers with your learning facilitator.

Part B

Note: You do not need to complete Part B if you have already done Part A.

Chemical weathering involves changes that result in new materials. Read the following situations. Then make some interpretations. Answer questions 6 to 9.

Situation 1

You decide to build a doghouse for your new puppy. You take some wood and some iron nails outside. Just after you begin, it starts to rain, so you leave the supplies in the yard and run into the house.

The next day when you return, you notice that the nails are covered with orange spots. When you pick up a nail, the orange colour rubs off onto your hand. You realize that the nails have started to rust.

Interpretations

6. a. Is rust softer or harder than the iron nail?

____

   b. How do you know?

____

____

7. What evidence is there that rust is a different material from iron?

____

____

8. Which is more likely to be broken into smaller pieces, the iron or the rust?

____

Situation 2

Another day you are writing on a blackboard during lunch. You accidentally drop a piece of chalk into your glass of soda pop. You notice that the chalk starts to fizz. When you empty the pop out of the glass, you notice that the chalk is much smaller and has lots of tiny holes in it.

Interpretations

9. a. Is this an example of mechanical or chemical weathering?

____

b. Give a reason for your answer.

Check your answers with your learning facilitator.

Activity 3: Gathering More Evidence

The explanation for chemical weathering sounds reasonable. The observations from Activity 2 support the explanation. But scientists are always trying to gather more observations to support, modify, or reject their explanations. For example, the part of the explanation about rivers disappearing and flowing underground needs support.

To test this part of the explanation, scientists put coloured dye in the water of a disappearing river. If water coloured by the dye appears in a cave, this is good evidence that the water has travelled through the ground into the cave.

If the water contains dissolved calcium carbonate, the calcium carbonate should be left when the water evaporates. Evidence supporting this is found in the caves. Water dripping from the top of caves could evaporate and form stalagmites and stalactites often found in limestone caves. Scientists tested samples of stalagmites and stalactites and found that they were made of calcium carbonate. This is more evidence that water containing carbonic acid dissolves rock containing calcium carbonate.

A scientific explanation is only useful if it can be tested. The best explanations can be widely used to explain how natural processes work everywhere, not just in isolated cases. Another way to test a scientific explanation is to make predictions based on the explanation. If the prediction is correct, the explanation gains support. If the prediction is incorrect, the explanation may need modification.

__Acid rain:__ rain with a very high acid content resulting from air pollution

Now use these ideas about scientific prediction as you think about another kind of acid caused by human action, something called **acid rain**. Acid rain forms as the result of materials that people add to the air. These chemicals come mainly from the chimneys of homes, the smokestacks of industries, and automobile exhaust. These gases join with the moisture in the air, or mix with rain, to form acids that return to the Earth when it rains and snows. This is acid rain.

Scientists predict that as more of these gases are added to the air, rock containing calcium carbonate should weather more quickly. Examples of rock structures that show effects of chemical weathering are buildings with limestone and marble exteriors, and the Sphinx. Are these materials being changed by acid rain? What would you expect to happen?

7 Science Directions

For more information on acid rain and photographs showing examples of chemical weathering involving acid rain, see page 307 of *Science Directions 7*. Answer the following questions.

1. Predict what should happen as more and more gases from automobiles and industries are added to the air.

   ____

   ____

2. Describe how scientists could test the prediction.

   ____

   ____

   ____

   ____

3. Cleopatra's Needle is the name of a monument that was built in Egypt over 3 000 years ago. Egypt's weather is warm and dry. Until 100 years ago, the carvings on the sides of the monument were sharp and clear. In 1880, Cleopatra's Needle was taken to New York City. Its carvings are now badly worn down.

   a. Do the observations about Cleopatra's Needle support the idea of chemical weathering?

      ____

   b. Explain why or why not.

      ____

      ____

      ____

      ____

4. Kim tried to explain chemical weathering to her grandfather. He smiled, then told her a story about gnomes. He described gnomes as small little old men who live in caves and guard buried treasure. The gnomes dig caves in limestone, leaving stalactites and stalagmites so that it is more difficult for their larger enemies to run through the caves. Gnomes have a magic power to make themselves invisible whenever people approach. Kim's grandfather also explained that what she called chemical weathering on the Earth's surface was really caused by the gnomes when they went out to search for more building materials. Gnomes chipped off small pieces of limestone, marble, and sandstone to build their cities in caves deep underground, much deeper than people have ever been.

   Kim told her grandfather that although she enjoyed the story about the gnomes, it still wasn't a scientific explanation. "Why not?" he asked her.

   Explain why the "gnome idea" is not a scientific explanation.

Discuss your answers with your learning facilitator.

Activity 4: Biological Weathering

Biological weathering: the weathering caused at least in part by the action of living things

7 Science Directions

The activities of some plants and animals can cause rocks to weather. Biology is the study of living things. **Biological weathering** is weathering caused by living things. Read Biological Weathering on page 308 of *Science Directions 7* to find out how plants and animals cause the break up of rocks. Also read Soils from Weathered Rocks on the same page to find out how soil that supports living things has been partly made by the action of living things. Rock, soil, and living things are connected.

Biological weathering involves living things, but as you have learned from your textbook reading, biological weathering is usually accompanied by mechanical or chemical weathering.

Do either Part A or Part B.

Part A involves taking a field trip to find examples of biological weathering, and describing your observations.

Part B involves answering questions 4 to 9 comparing mechanical and chemical weathering with biological weathering in order to help you get a better understanding of biological weathering.

Part A

Note: You do not need to complete Part A if you wish to do Part B.

Plan a hike that will take you to a variety of locations. These locations might include an open field, an area with lots of trees, a stream or river bank, as well as locations near buildings. Look for examples of biological weathering. Keep notes so that you can describe three examples and explain what evidence there is that biological weathering has occurred.

1. a. Describe your first example of biological weathering.

____

____

   b. What evidence indicates that biological weathering has occurred?

____

____

____

2. a. Describe your second example.

____

____

   b. What evidence indicates that biological weathering has occurred?

____

____

____

3. a. Describe your third example.

____

____

____

b. What evidence indicates that biological weathering has occurred?

____

____

____

Discuss your answers with your learning facilitator.

Part B

Note: You do not need to complete Part B if you have already done Part A.

4. Describe one example of mechanical weathering.

____

____

5. Describe one example of chemical weathering.

____

____

6. Describe one example of biological weathering.

____

____

7. How is biological weathering different from mechanical and chemical weathering?

8. How is biological weathering similar to mechanical and chemical weathering?

9. How are rock, soil, and living things connected?

Check your answers with your learning facilitator.

Activity 5: Understanding Weathering

Read each of the following descriptions. Then make the necessary interpretations to try to explain how each change might have happened. If you have difficulty with some of the explanations, review the previous activities along with the associated textbook readings for this section to help guide you.

1. You take four pennies out of your pocket and look carefully at their colour. The pennies with dates of 1991 and 1990 are bright and shiny. The ones with dates of 1979 and 1982 are dark and dull. Explain what might have happened to the older pennies.

   ____

   ____

   ____

2. You are walking in a newly developed part of a city. The concrete sidewalks are smooth and level. In the older part of the city in which you live, the sidewalks have lots of cracks, and some parts of the walk are raised up several centimetres. Explain what might have happened to the sidewalks in your part of the city.

   ____

   ____

   ____

3. For your summer holidays you travel to Quebec. You notice that many of the cathedrals have metal steeples, of a green colour. The new church in your town in Alberta has a copper-coloured steeple. When you ask, you are told that all the steeples are made from copper. Explain what might have happened to the steeples in Quebec.

   ____

   ____

   ____

4. When hiking through the woods, you see a large tree growing through a rock. The rock seems to be split into two parts. Explain what might have happened to the rock.

   ____

   ____

   ____

Check your answers with your learning facilitator.

Follow-up Activities

If you had difficulties understanding the concepts in the activities, it is recommended that you do the Extra Help. If you have a clear understanding of the concepts, it is recommended that you do the Enrichment.

Extra Help

Solid materials such as rock are broken down into smaller pieces like sand. You can do this by hitting a rock with a hammer. When it occurs naturally, without the help of a person or a machine, the process is called weathering.

Another way that solid materials weather is by changing colour. For example, if you do not paint a fence, the wood will slowly turn grey.

To understand weathering, scientists develop explanations about what causes things to weather. Scientists divide the causes into three groups. Each group has a different name. The three types of weathering are

- mechanical weathering
- chemical weathering
- biological weathering

Mechanical weathering starts with temperature changes. Solid material changes size when heated and cooled. Solids expand (grow larger) when heated, and contract (grow smaller) when cooled. After many expansions and contractions, a solid may form small cracks.

Water plays an important role in the next stage of mechanical weathering. Water expands when it freezes. It can seep into cracks of a rock. If the water freezes, expansion can widen the crack in the rock. When this is repeated many times, the rock can break into two smaller pieces. This is called ice wedging.

Chemical weathering happens when the material is changed into a different material. This is called a chemical change. One of the most common substances involved in chemical weathering forms when acid is added to water. This occurs naturally when carbon dioxide from the air mixes with rain to form carbonic acid. This acid can dissolve calcium carbonate. Limestone, marble, and sandstone contain calcium carbonate. When the acidic water dissolves the calcium carbonate, holes are left in the rock. The rock has been chemically weathered.

Biological weathering occurs when living things help the weathering process. Plants such as dandelions and trees can grow through small cracks. As the plants grow larger, the size of the crack is increased. Animals can dig up rocks. Mechanical and chemical weathering are more likely to wear down a rock that is exposed than one that is buried underground.

> You may choose to do only Part A, or Part B, but you may do both Part A and Part B if you wish.

Part A lets you imagine that you are a rock. You are then to write an imaginary story about changes that would occur to you as you are changed into smaller pieces by weathering.

Part B reviews weathering by having you use words you studied about in Section 2 to complete sentences.

Part A

Imagine that you are a rock. Write an imaginary story about how you are changed into several pieces by weathering. Describe what happens to you. Use diagrams if you wish.

Use all of the words in the word list below. Try to use the words in a way that will show that you understand what they mean.

Word List

- biological weathering
- calcium carbonate
- carbon dioxide
- chemical weathering
- contract
- expand
- ice wedging
- mechanical weathering
- temperature

Write your story here. There is more space on the next page if you need it.

Breaking Up Is Hard to Do

Check your answers with your learning facilitator.

Part B

Fill in the blanks below with the words from the following word list. You will only use ten of the words. Draw a line through each word as you use it.

Word List

animals	limestone
biological	marble
calcium carbonate	mechanical
carbon dioxide	plants
carbonic	rock
chemical	soil
contract	temperature
expand	weathering
ice wedging	

1. The process of rocks being broken down into smaller pieces is called ________________.

2. ________________ weathering involves the action of living things.

3. During ________________ weathering solids change into different materials.

4. The weak acid that forms when rain mixes with ________________ is called ________________ acid.

5. When solids are cooled, they ________________.

6. Cracks can form in rocks during changes in ________________.

7. Water will ________________ when it freezes.

8. ________________ and ________________ are types of rock that are affected by chemical weathering.

9. a. List the seven words that you did not use.

- ______________________________
- ______________________________
- ______________________________
- ______________________________
- ______________________________
- ______________________________
- ______________________________

b. Write a sentence using three of these words. Try to use the words to show that you understand one way the three words are connected.

____

____

____

Check your answers with your learning facilitator.

Enrichment

Make the necessary interpretations to answer the following questions.

1. The coal mine underneath Turtle Mountain may have helped to cause the Frank Slide. The night before the slide, the weather was very cold, with a heavy frost. Explain how weathering might also have helped cause the slide.

____

____

____

____

____

____

____

2. What evidence would you look for to help prove or disprove your explanation for question 1? Explain how the evidence would help.

3. Imagine you work at a garden centre that sells large planters for growing flowers in the summer. You must explain to the people who buy your planters why they should empty them before the winter, or at least make sure the material in the planters is quite dry. Write an explanation for the buyers of your planters.

Check your answers with your learning facilitator.

Conclusion

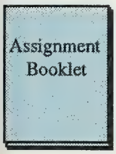
Scientists develop explanations to explain natural events. They gather evidence to decide if the explanations should be changed, rejected, or accepted. Scientists are always trying to improve their explanations.

To explain how rock can be broken into smaller pieces, scientists have developed the idea of weathering. There are three different ways in which rocks can be broken down into smaller pieces.

Mechanical weathering occurs when rock is broken into smaller pieces, but there is no change in the type of material. The rock looks the same except for its size.

Chemical weathering occurs when the material is changed. It may change colour, or dissolve in water because of the change.

Biological weathering is assisted by living things. Rock can be exposed or broken by plants or animals. Mechanical and chemical weathering are also at work during biological weathering.



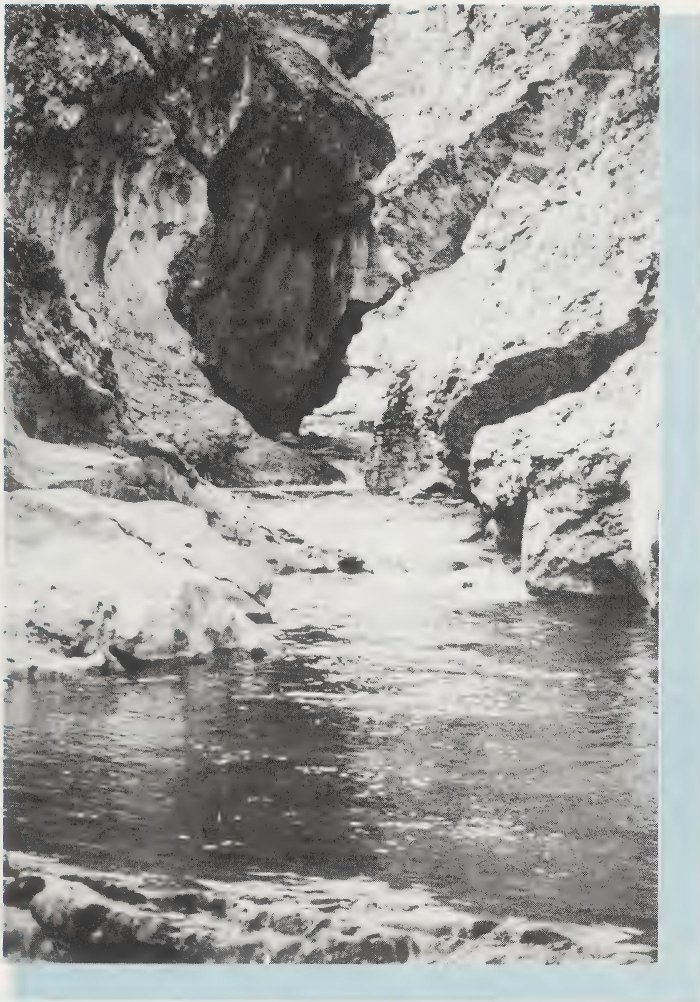
ASSIGNMENT

Turn to your Assignment Booklet and do the assignment for Section 2.

Section

3

Erosion by Water



In Section 2 you learned that weathering involved the natural breaking down of solid materials into smaller pieces. You will now be studying another important process which changes the landscape – erosion. The process of erosion involves the wearing away and movement of rock materials from place to place. The movement may be caused by gravity, moving water, ice, or wind.

The photograph shows how the moving water of a river has the ability to erode the river banks and the bottom of the channel in which it flows.

In this section you will look at the effects of moving water.

Activity 1: Erosion by Moving Water

Look at the photograph of the Grand Canyon shown on pages 310 and 311 of *Science Directions 7*. Think about how it may have been formed. Then read Erosion by Moving Water on page 311 of the textbook to find out how scientists explain the formation of the Grand Canyon.

Erosion: the wearing away and movement of rock materials from place to place

Most streams and rivers are important causes of **erosion**. As the water flows, it wears down rock into smaller pieces and carries away rock fragments. This is an example of erosion caused by water.

It is often difficult to study streams and rivers by direct means. The water in them may be too muddy to see into. Streams and rivers may flood, dry up, alter course, or the changes in them may occur so slowly that it may be difficult to observe the changes during one person's lifetime. It has taken millions of years for erosion to carve out the Grand Canyon.

Model: a diagram, description, or a miniature representation of something

Although many forms of scientific investigations are best done in natural environments, some are better done under laboratory conditions. Scientists often use **models** to help them study something. Scientists find that a useful way to study the behavior of running water is to observe how it behaves in a model such as a stream table. They can then apply what they learn to explain how streams and rivers cause erosion.

Read Modelling Moving Water on page 311 of your textbook. Pay attention to how and why scientists use stream tables to study the effects of erosion by water.

Now you will get some practice in using a model to investigate the effects of running water on rock fragments of different sizes.

Do either Part A or Part B.

Part A involves using a stream table and answering questions 1 to 4.

Part B involves using a large jar and answering questions 5 to 8.

7 Science Directions

Part A

Note: You do not need to complete Part A if you wish to do Part B.

You are going to use a stream table to study the effects of running water on rock fragments of different sizes. This investigation is based on the information given under Moving Rock Fragments on page 312 of the textbook. Refer to the diagram on page 312 to help you set up the materials for this investigation.

Materials You Need

- stream table
- water
- rock fragments of different sizes:
  - sand (very small)
  - gravel (small)
  - pebbles (medium)

Steps to Follow

Step 1: Set up the stream table as shown in the diagram on page 312 of your textbook. You may ask your learning facilitator to help you.

Step 2: Mix the rock fragments and put them in the stream table to a depth of about 3 cm.

Step 3: Fill the bottom part of the stream table with water, to represent a lake.

Step 4: Start by dripping water a drop at a time into the stream table. Then increase the flow of water to a gentle flow from the top of the stream table. The water represents a stream flowing over the rock fragments. Observe the effect of the moving water on the rock materials. Record your observations in the observations chart which follows.

Step 5: Gradually increase the water flow to medium speed. Observe the effects on the rock fragments and record your observations in the observations chart which follows.

Observations

Flow of Water	Effect on Rock Fragments
dripping	
gentle flow	
medium speed	

Questions to Answer

1. What happened to each size of rock fragment when the water ran slowly?

    - sand ____________________
    - gravel ____________________
    - pebbles ____________________

2. What happened to each size of rock fragment when the water flowed more quickly?

    - sand ____________________
    - gravel ____________________
    - pebbles ____________________

3. Predict what might happen to each size of rock fragment if you increased the steepness of the slope of the stream table.

    - sand ____________________
    - gravel ____________________
    - pebbles ____________________

4. Describe how you would go about experimenting to test the effects of moving water on different slopes of sand.

____

____

____

____

____

____

Check your answers with your learning facilitator.

Part B

Note: You do not need to complete Part B if you have already done Part A.

You are going to use a large jar to study the effects of moving water on rock fragments of different sizes.

Materials You Need

- large transparent jar with lid
- water
- rock fragments of different sizes:
  - sand (very small)
  - fine gravel (small pieces of gravel)
  - pebbles (medium pieces of gravel)

Steps to Follow

Step 1: Mix the rock fragments and put them in the jar to a depth of 3 cm.

Step 2: Add water to the jar until it is two-thirds full. Put the lid on the jar.

Step 3: Start by very slowly swirling the jar. Then gradually increase the speed of the water. The water represents a stream flowing over the rock fragments. Observe the effect of the moving water on the rock materials. Record your observations in the observations chart which follows.

Step 4: Gradually increase the water to a medium speed. Observe the effects on the rock fragments and record your observations in the observations chart which follows.

Observations

Speed of Water	Effect on Rock Fragments
very slow	
slow	
medium speed	

Questions to Answer

5. What happened to each size of rock fragment when the water was moving very slowly?
   - sand ______________________________
   - fine gravel ______________________________
   - pebbles ______________________________

6. What happened to each size of rock fragment when the water flowed more quickly?
   - sand ______________________________
   - fine gravel ______________________________
   - pebbles ______________________________

7. Predict what might happen to each size of rock fragment if you swirled the water as fast as you could.
   - sand ______________________________
   - fine gravel ______________________________
   - pebbles ______________________________

8. Imagine that stream *A* flows down a very steep slope through a mixture of sand, pebbles, and fine gravel. Stream *B* flows down a nearly level slope through similar material. Predict what you would expect to see being carried by each of these streams. How can the *jar* model you just used help you predict differences in what will happen to the rock fragments in each stream?

____

____

____

____

____

Check your answers with your learning facilitator.

Activity 2: Settling Sediments

During Activity 1 you observed that water carried rock fragments. Fast moving water moved bigger rock fragments than slow moving water. In your own natural surroundings you may have noticed that real streams and rivers also carry rock fragments. This can most easily be seen where streams enter relatively still bodies of water such as ponds or lakes.

Turn to page 322 of *Science Directions 7* and look at the middle photograph. Notice the murky colour of the water where the river enters the lake. This is caused by rock fragments being carried by the river. The relative clearness of the lake further from shore shows that rock fragments settle out of still water.

In Activity 1 you also learned that water flows faster down greater slopes than down lesser slopes. At the same time you may have realized that when there is more water in a stream, it can carry more rock fragments.

The amount of rock fragments carried by streams depends on

- the size of the fragments
- the slope of the land the stream is flowing over
- the quantity of water in the stream

Boulders: very large rocks

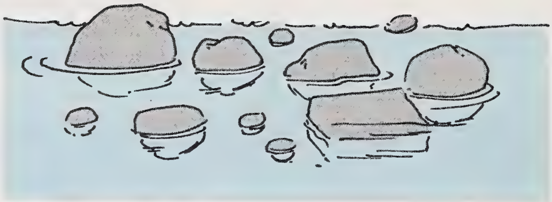
Pebbles: rounded stones, usually 0.5 cm to 2 cm in diameter

Sand: particles of rock, usually granular and gritty (larger than clay but smaller than pebbles or gravel)

Silt: finely divided soil particles or sediments (finer than sand but not as fine as clay)

Clay: finely divided particles of rock with grain sizes of less than one five-hundredth of a millimetre

Gravel: rock fragments of various sizes larger than grains of sand



Very large rocks are called **boulders** or cobbles. Smaller pieces are called **pebbles**. Fine pieces are called **sand**. Smaller still are rock fragments called **silt**. The smallest pieces are called **clay**. **Gravel** is the name given to rock fragments of various sizes (usually pebble size and larger). As these rock fragments are carried along by water, they bounce along the bottom, wearing down the river bed by friction as they are moved along it. At the same time the rock fragments are themselves worn down as they rub against the river bed and against each other. Often, the water wears the pebbles into rounded shapes with smooth surfaces.

Different words are used for different kinds of streams: brooks, tributaries, rivers, meanders. Think about these different words. What do these terms mean?

Streams, Rivers, and Tributaries

Runoff: rainwater that runs across the surface of the ground instead of sinking into it

After a rainstorm rainwater may flow directly into streams and brooks. This is called **runoff**. Rainwater may also sink into the earth and appear somewhere nearby from an underground flow or spring. Small streams often start in mountainous areas where moisture is plentiful. Mountain streams flow down steep slopes relatively quickly, and can carry fairly large rock fragments.

Tributaries: streams that flow into rivers

As more and more streams flow down the mountain slopes, they join together to form rivers. Streams that flow into rivers are called **tributaries**. As more tributaries join as one river, the amount of water in the river increases. Rivers and tributaries can carry lots of rock fragments when the water level is high.

As a river flows into areas where the land is flat, it may spread out and become wider. The river now flows more slowly. As the speed of the water decreases, the river can carry fewer rock fragments.

Sediment: earth, stones, sand, and so on, deposited by water, wind, or ice

At some point along its course, a stream slows down. It may happen that the stream's bed widens, and as the water spreads out, its speed slows. Or the stream may slow down because it is flowing across nearly flat ground. As the stream slows, it can carry fewer rock fragments. The rock fragments the stream can no longer carry are set down, or deposited. These deposits are called **sediments**.

At the beginning of this section you examined a photograph of the enormous canyons cut by the Colorado River. Canyons have steep, straight sides because the river has cut straight down into the rock beneath. As time passes, the rocks at the top of these valleys become worn down by weathering. As a result, the valley becomes V-shaped. Rivers in canyons and in steep, V-shaped valleys are said to be younger rivers, because the sides of their valleys have not been worn down by weathering as much as the sides of valleys of older rivers.

Meander: a type of curve in the bed of a river or stream

When a river reaches its lowest level, it cannot dig a channel any deeper. Instead, it may start to move from side to side and make a curving bed. These changing curves are called **meanders**. A meandering river continually changes the landscape.

As a river meanders, the water on the outside of the curves moves fast and erodes away the bank. The water on the inside of the curves moves slower and deposits sediments. Sometimes a meandering river will cut part of the river off from the rest. When this happens, the lake formed is called an oxbow lake. The photograph at the bottom of page 323 in your textbook shows an oxbow lake. They have the shape shown because they were formed by a meandering river.

7
Science Directions

For more detailed information and photographs showing the features discussed, read pages 314 to 316 and pages 321 and 322 of your textbook.

You will now do an investigation and answer some questions under observations to help you understand how rock fragments settle to form sediments. Then you will apply what you learned in the investigation and from the notes earlier in this activity to answer the questions under Interpretations.

Materials You Need

- transparent jar with lid
- water
- mixture of rock fragments:
  - sand
  - silt
  - small gravel

Steps to Follow

Step 1: Fill one third of the jar with the rock fragment mixture. Stir the rock fragments to ensure they are well mixed.

Step 2: Add water to almost fill the jar; then put on the lid. Turn the jar upside down and back and forth about ten times until the rock fragments are well mixed in the water.

Step 3: Set the jar on a table and leave it for a few minutes until most of the rock fragments have settled.

Observations

1. a. Did the big rock fragments settle near the bottom or near the top of the jar?

   ____

   b. Why?

   ____

   ____

2. a. Did the small rock fragments settle near the bottom or near the top of the jar?

   ____

   b. Why?

   ____

   ____

Interpretations

3. As a fast river begins to slow down, rock fragments start to settle on the bottom of the river. In what order will the following rock fragments settle?

   sand, fine gravel, silt, pebbles, clay

   List the rock fragments from the first to settle to the last to settle.

   first to settle ______________

   ____

   ____

   ____

   last to settle ______________

4. Imagine that you are in a valley with no water flowing through it. You are trying to figure out if a river once flowed through the valley. Think about each of the following observations. Look back at the information in this activity if you need help.

   If the observations support the idea that a river once flowed through the valley, write *yes* in the space. If the observations do not indicate that a river once flowed through the valley, write *no* in the space. Then briefly explain your answer.

   a. ______ You find lots of smooth, well-rounded pebbles and gravel.
   Explanation:

   ____

   ____

   b. ______ There are lots of bushes and grass.
   Explanation:

   ____

   ____

   c. ______ The valley is shaped like a large "V."
   Explanation:

   ____

   ____

   d. ______ There is a lake shaped like a "C," with no water flowing into or out of the lake.
   Explanation:

   ____

   ____

   e. ______ There is a very large boulder, about the size of a large truck, sitting on the ground.
   Explanation:

   ____

   ____

Deltas

Delta: land that has formed at the mouth of a river from sediments carried by the river

Turn to page 324 of *Science Directions 7*. Read the information under Deltas to find out how deltas are formed and how this type of landform got its name.

5. Think back to the experiments you did with rock fragments and water. Describe what the sediments in a **delta** might look like if you dug down. What kind of material might be found in the delta? What kind of material might be found farther out in the water, just beyond the delta?

____

____

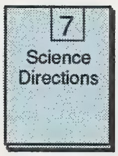
____

____

____

Check your answers with your learning facilitator.

Activity 3: The Pounding Surf



You have already learned how streams and rivers cause erosion. Now turn to page 317 of your textbook and read The Pounding Surf and Did You Know? to find out how waves cause erosion along shorelines.

Next turn to page 324 of your textbook and read Sediments Moved by Seas and Lakes. Find out how deep bays may be formed on one part of the shore and how new land may be built up at some other point along the shore. The photograph at the bottom of the page shows how **deposition** was involved in forming Point Pelee in Lake Erie.

Deposition: the settling of sediments carried by wind or water
In this case deposition describes the settling of sediments from water after they have been moved by waves.

In the space provided, describe changes that can occur in shorelines. Use diagrams if you wish. In your description, show that you understand the difference between erosion and deposition and how they work together to change shorelines.

Check your answers with your learning facilitator.

Activity 4: Water Underground

7 Science Directions

Groundwater: water accumulated beneath the Earth's surface in the pores of rocks, spaces, cracks, and so on

Porosity: the amount of space between particles
The porosity of soil means how much space there is between the particles making up the soil.

As an introduction to this topic, read page 328 of the textbook and think about the questions that are asked.

When snow melts in the spring, or after a rainfall, some of the water flows along the surface of the ground and into streams, rivers, and lakes. Not all the water on the soil becomes runoff. Some of it sinks into the ground. This water is called **groundwater**.

The water that sinks into the ground enters the surface layers of soil. You have found that soil is partly composed of finely weathered rock. Just as there are many kinds of rock, so there are many different types of soils. Soil with great **porosity** will let water sink into it easily. Soil with low porosity will keep water on the surface longer because there are not as many spaces for the water to move into.

Most soil is a mixture of gravel, sand, silt, clay, and the remains of organisms that are decomposing. For this investigation, you will compare the porosity of gravel, sand, potting soil, garden soil, and clay to help you understand porosity better.

To compare the porosity of soil samples, you can measure how much water you can pour into each sample. The sample that holds the most water has the highest porosity. The sample that holds the least water has the lowest porosity.

Materials You Need

- small jar or can
- water
- graduated cylinder or measuring cup
- soil samples:
  - dry gravel
  - dry sand
  - dry potting soil
  - dry garden soil
  - dry clay

Steps to Follow

Step 1: Fill the jar with dry gravel.

Step 2: Measure 100 mL of water into the graduated cylinder.

Step 3: Slowly pour the water from the graduated cylinder into the jar of gravel, until it will hold no more water.

Step 4: Observe how much water is left in the cylinder. Subtract from 100 mL to find out how much water the jar of gravel holds. Record this amount in the observations chart which follows.

Step 5: Empty and dry the small jar.

Step 6: Repeat steps 1 to 5 for each soil sample.

Observations

Soil Sample	Amount of Water Added (mL)
dry gravel	
dry sand	
dry potting soil	
dry garden soil	
dry clay	

Questions to Answer

1. List the soil samples from highest porosity to lowest porosity.

   highest porosity ____________________

   ____

   ____

   ____

   lowest porosity ____________________

2. a. Through which type of soil material will water flow quickest?

   ____

   b. Why?

   ____

   ____

3. a. Predict how much water you could add to a sample that was half gravel and half sand.

____

____

b. Try mixing equal amounts of sand and gravel. Then add water to fill the container. What amount of water did you need to add?

____

c. Was this what you expected? ______________
If it was different, try to explain the difference.

____

____

4. a. Which type of soil would have most runoff after a rainfall?

____

b. Explain why.

____

____

5. a. Which type of soil would contain the most groundwater after a rainfall?

____

b. Explain why.

____

____

Check your answers with your learning facilitator.

Activity 5: The Water Table

In Activity 4, you poured water onto different samples of soil. There were spaces between the particles in each of the soil samples you used. Before you poured the water in, these spaces were filled with air.

When water falls on the ground, it works its way down through the spaces in the soil. Eventually it reaches rock that does not have spaces large enough for the water to pass through. As rain continues to fall, the level of the water above this rock rises. This level is called the **water table**.

Water table: the highest level that water sinks to in the ground

Between rainfalls all plants – the crops in fields, the trees in the woods, and the grass in the backyard – rely on the water in the soil for their needs. They take in this water through their roots.

Now turn to page 330 of your textbook and read Water on the Surface. Find out how rainfall and snowfall affect the amount of **surface water** available.

Surface water: the water that forms on the surface of the ground in areas where the water table reaches ground level Streams, rivers, lakes, and sloughs are examples of surface water.

Next you are going to set up a model for observing how rainwater might form groundwater and various kinds of surface water. This model is the same as that described for Activity 6-13 on pages 330 and 331 of your textbook, except that the instructions are put into the design format that is used throughout this Module Booklet. In this model rain is represented by you pouring water onto sand. In this way you can watch the affect rain has when it falls on dry ground. By making holes or hollows of different depths in the sand, you can see how water fills sloughs, lakes, and wells.

Refer to the diagram on page 330 of your textbook to help you set up the following model.

Materials You Need

- shallow container that will hold water (minimum 30 cm × 20 cm × 5 cm)
- open-ended plastic tubing, about 1 cm in diameter
- sand
- water
- beaker or other convenient small container

Steps to Follow

Step 1: Half fill the container with dry sand, leaving a slightly uneven surface.

Step 2: Clear one side to the bottom of the container ("lake").

Step 3: Make a shallow hollow on the other side of the container ("slough").

Step 4: Position two tubes in the sand, making sure they remain upright. Try to keep the inside of the tubes as clear of sand as possible. Push one nearly to the bottom of the container, and the other only about 2 cm into the sand (deep and shallow wells).

Step 5: Pour a little water very slowly from the beaker onto the sand in the container. Observe what happens to the water.

Step 6: Continue to pour until water appears in one of the holes in the container. Note where the water first appears.

Step 7: Continue to pour water gently into the container. Note when water appears in the holes you have made and where it appears on the surface.

Observations

1. When water was first poured onto the sand, where did it go?

____

____

2. Which hole first showed water?

____

3. Where did water appear next?

____

4. Where did water appear last?

____

____

Interpretations

To answer questions 5 to 10, you will need to apply what you learned about the behavior of groundwater from your model set up.

Read the captions and examine diagrams (**a**), (**b**) and (**c**) on page 331 of your textbook. Answer the following questions which help explain the behavior of the groundwater in Johann's and Cheryl's camp as shown in the diagrams.

7
Science Directions

5. When the rain fell in the spring, what happened to it?

____

____

6. How did water get into the wells, streams, and slough?

____

____

7. Why was one of the wells dry when Cheryl visited the camp?

____

____

8. What happened to the slough in the summer?

____

____

9. How does the *water table* model help explain the appearance and disappearance of surface water?

____

____

10. Why do scientists use models?

____

____

____

____

Check your answers with your learning facilitator.

Follow-up Activities

If you had difficulties understanding the concepts in the activities, it is recommended that you do the Extra Help. If you have a clear understanding of the concepts, it is recommended that you do the Enrichment.

Extra Help

Moving water causes erosion because it wears rock down into smaller pieces and moves the pieces from place to place.

During a rainstorm, some of the rain that falls on open ground sinks into the ground. This is called groundwater. Water that does not sink into the ground is called runoff. Runoff forms streams and rivers. Streams and rivers flow into lakes and oceans. Moving water causes erosion below the ground, on the surface of the ground, and on shorelines.

Look at the following word list. If you do not know what a word means, look back through this section to find out how the word is used.

Word List

boulders	observation	shore
canyon	oceans	shoreline
clay	oxbow	silt
delta	pebbles	snow
deposition	pores	soil
erosion	porosity	steep
flood	rain	stream
gravel	river	surface
groundwater	rock	table
inference	runoff	tributaries
lake	sand	water
meandering	sediments	weathering
model	soil	valley

Once you think you understand the words, test yourself by doing the following crossword puzzle. Some of the clues may seem to fit more than one word. You will not use all the words. A word is used only once in the crossword puzzle. Do the crossword, using a pencil so that you can change words to make everything fit.

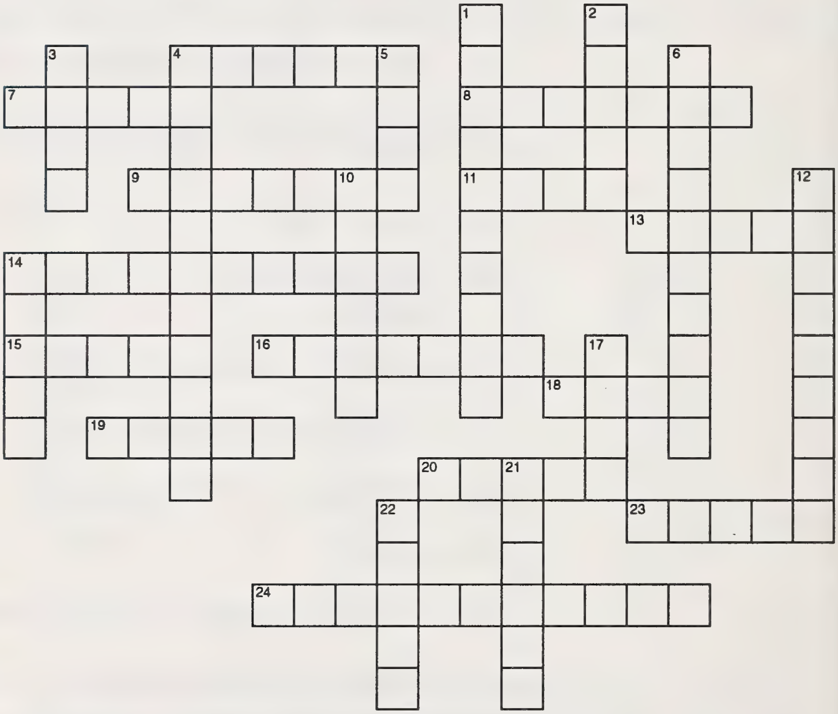
Across Clues

4. sediment larger than sand
7. a form of moving water that causes erosion on the Earth's surface
8. sediment larger than sand
9. Runoff is called ________________ water.
11. one source of runoff
13. what waves erode
14. the type of river that winds back and forth on a fairly level surface
15. a collection of sediment often found where a river enters an ocean
16. wearing away of rock and the moving of the rock fragments from one place to another
18. a source of runoff
19. A river flowing down a ________________ slope carries lots of rock fragments.
20. what happens when more runoff enters a river than it can hold
23. the holes into which groundwater seeps
24. the name for streams that flow into rivers

Down Clues

1. As a stream or river slows, rock fragments settle to the bottom.
2. a lake formed from a meandering river
3. sediment smaller than sand
4. water contained in the soil
5. one place where a delta might form
6. rock breaking down into smaller pieces

10. a landform that has very steep sides, caused by river erosion
12. rock fragments deposited by a river
14. A stream table can be used to make a ______________ of a river.
17. sediment larger than clay and silt
21. the largest bodies of water on Earth
22. The water ______________ is the level at which the soil cannot hold any more groundwater.



Check your answers with your learning facilitator.

Enrichment

Read There's Gold in Them There Rivers! on page 313 of your textbook. Find out how miners were able to separate gold from other rock materials in rivers.

Do Activity 6-6 which is described on page 313 of your textbook. Use the materials that are stated and follow steps 1 to 5 given under the Procedure. See if you can separate heavier rock materials (lead shot or another heavy substitute for gold) from lighter rock materials.

Make the necessary interpretations to answer the following questions.

1. Why were you able to separate the "gold" from the other rock fragments?

2. What force pulls particles to the bottom of moving water?

3. What force keeps particles from settling out of the water?

4. How do these two forces act together to allow you to find and remove the lighter substances after swirling them around in the water?

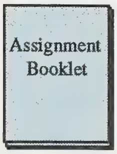
5. Imagine that you find an old river bed where a river once was but has now dried up. How could looking at the sediments help you infer what the size and speed of the river used to be?

Check your answers with your learning facilitator.

Conclusion

Erosion is the wearing away and movement of rock materials from place to place. Moving water causes much of the wearing away and the movement of rock fragments. Water erosion causes rivers to change course and shorelines to change. Water erosion also occurs underground.

Moving water causes many changes to the Earth. Most of these changes are slow, but the long-term effect can be as dramatic as the Grand Canyon.



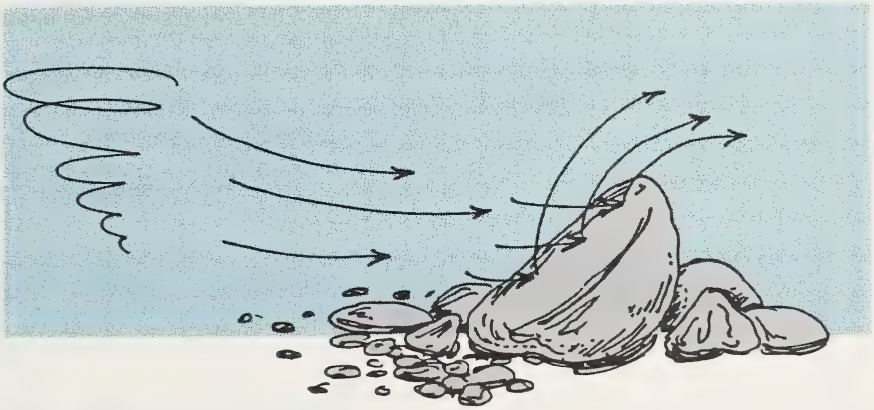
ASSIGNMENT

Turn to your Assignment Booklet and do the assignment for Section 3.

Section

4

Erosion by Wind



In Alberta, we experience a relatively dry climate. In fact, some parts of southern Alberta are almost desertlike, with cacti growing well in the warm climate. This, coupled with the generally strong westerly winds, can produce a situation in which small weathered particles are picked up and carried away. This is called wind erosion.

This section will take a brief look at the causes and effects of wind erosion. By the end of this section you should be able to identify the features that result from wind erosion. You should also understand how wind erosion effects Alberta and how wind erosion can be controlled.

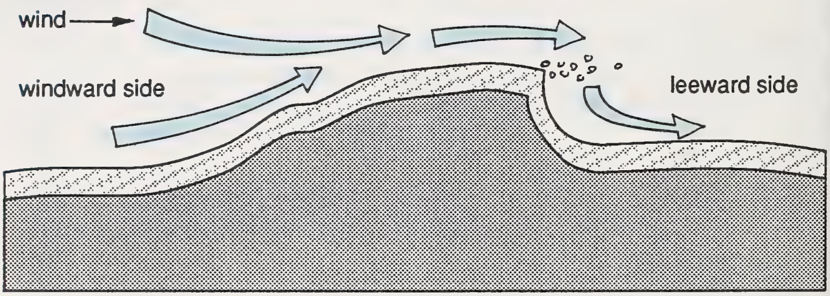
Activity 1: Blowing in the Wind

Read Blowing in the Wind on page 318 of *Science Directions 7*. Also examine the accompanying photograph on the same page. Pay attention to how rock particles can be eroded by wind. Notice that the ripples in the sand caused by blowing wind do not resemble the branching patterns left by water erosion.

You have felt the force of the wind. Think about the difference between riding a bicycle against a strong wind and riding a bicycle when there is no wind. The extra effort you must apply against the wind is because the wind is forcing you in the opposite direction.

The best example of the wind moving solid material occurs during an Alberta blizzard. In open areas, snow is blown around until it is deposited, either when the wind stops or when the snow is blown into a sheltered area protected from the wind. The force of the wind moves the snow from place to place.

Wind can also move sand, clay, and silt. When these sediments are deposited in drifts, they are called dunes. You can tell which direction the wind was blowing by the shape of the dune.



Windward: the side from which the wind is coming

Leeward: the side that is sheltered from the wind

The wind blows up the **windward** side of the dune, carrying sand grains with it. As it goes over the top of the dune, the sand is dropped, because the **leeward** side is sheltered. The calm air on the leeward side cannot carry as much sand as the strong wind on the windward side.

You will now try to make some models of sand dunes.

Materials You Need

- drinking straws
- dry sand
- newspaper

Steps to Follow

Step 1: Get several drinking straws and a cupful of dry sand. Make a pile of sand on a sheet of newspaper.

Step 2: Draw a diagram of the pile of sand in the Observations chart which follows.

Step 3: Blow gently along the surface of the paper. Try to make a tiny sand dune by blowing on the dry sand.

Step 4: In the following Observations space, draw a diagram of the sand dune you made. Label the leeward and windward sides, and the direction in which you were blowing.

Observations

Before Blowing Dry Sand	After Blowing Dry Sand

Steps to Follow (continued)

Step 5: Pour the sand back into the cup. Add enough water to make all the sand wet. Then pile the wet sand on a newspaper.

Step 6: Draw a diagram of the pile of wet sand in the Observations chart which follows.

Step 7: Blow gently along the surface of the paper. Try to make a tiny sand dune by blowing on the wet sand.

Step 8: Draw a diagram in the following Observations space.

Observations (continued)

Before Blowing Wet Sand	After Blowing Wet Sand

Interpretations

1. What are the two most important factors you have discovered that determine how much wind erosion occurs in a certain area?

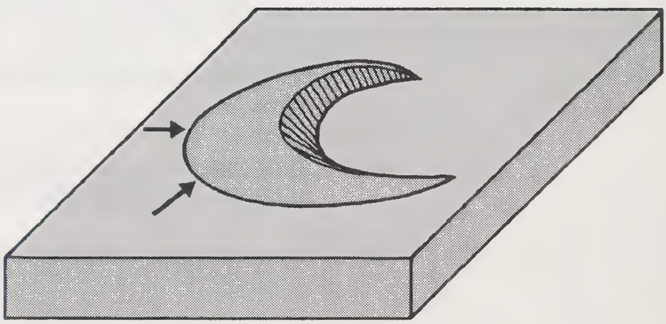
____

____

2. Predict how a sand dune might move if the wind continues to blow in the same direction for a long time.

____

____



3. Predict what will happen to soil being carried on the wind if the wind meets a solid object, such as that depicted in the following diagram.

Check your answers with your learning facilitator.

Activity 2: Controlling Wind Erosion

Read The Dirty Thirties on pages 318 and 319 of *Science Directions 7*. The reading discusses the problems that can be caused by wind erosion and how wind erosion can be controlled.

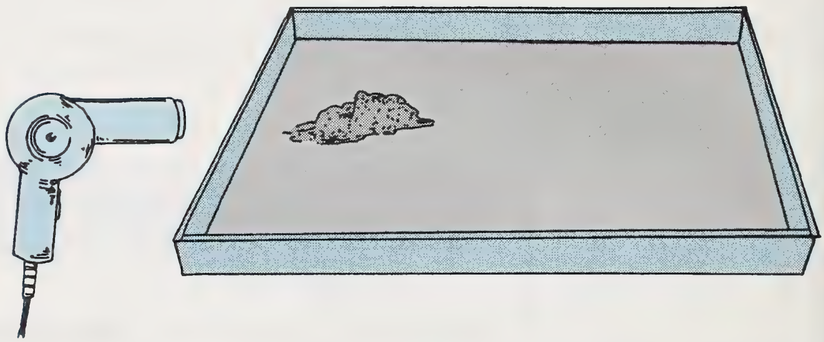
In Section 3 you have seen that the amount of water and the speed at which the water flowed had an effect on the size of rock fragments moved. Next you will do an investigation which has been adapted from Activity 6-9 on page 320 in your textbook. You will test what effect wind would have on soil particles of different sizes. You might choose sand and garden soil. Or you might want to use other easily obtainable materials to represent soil samples. For instance, you could use uncooked rice mixed with other cereal grains.

Question for Investigation

What effect does wind have on particles of different sizes?

Materials You Need

- hand-held dryer or small fan
- soil samples you have selected
- long, shallow box or tray (can be made by cutting down a large cardboard box to about 5 cm to 10 cm)
- plastic cup
- weights to hold cup in place



Steps to Follow

Step 1: Put the samples together at one end of the container.

Step 2: Turn on the hair dryer to the slowest speed. Slowly bring the hair dryer close to where the samples are and direct the *wind* at the samples so that it will blow them toward the other end of the container.

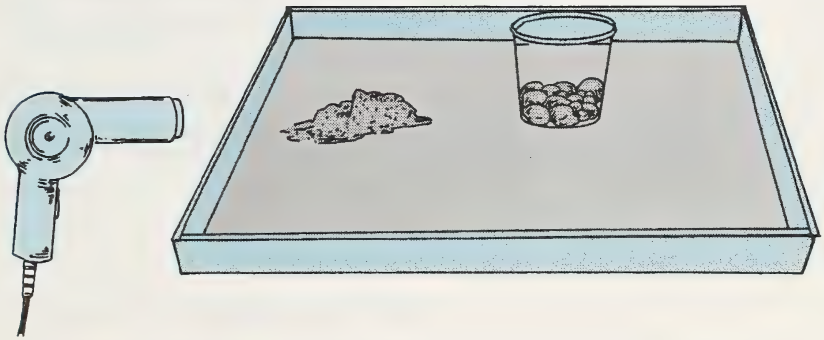
Step 3: Record which soil samples move the farthest and which move the least. If possible, measure the distance each moved. Record your observations in point form in the following Observations space.

Observations

Steps to Follow (continued)

Step 4: Gather the samples together again at one end of the container. Place an object such as a plastic cup with weights in it on the leeward (downwind) side of the samples.

Step 5: Now repeat step 2. Record what happens in the Observations space which follows.



Observations (continued)

Interpretations

1. Explain why some soil samples were blown farther than others (step 2).

2. Predict what would have happened if you had used the hair dryer at a higher speed.

3. Predict what would have happened if you had dampened the soil samples before you used the hair dryer.

4. Explain what happened when the cup was placed in the path of the wind.

5. How could planting trees reduce soil erosion by the wind?

Check your answers with your learning facilitator.

Note: There are no Follow-up Activities for this section. Read the Conclusion which follows. Then do the assignment for Section 4.

Conclusion

Wind erosion is caused by strong winds blowing over an area that has a covering of soil or sand and a dry climate. Ways to prevent soil erosion include keeping a grass cover on the land and planting trees to reduce the speed of the wind near the ground.

Assignment Booklet

ASSIGNMENT

Turn to your Assignment Booklet and do the assignment for Section 4.

Section

5

Erosion by Glaciers

Section 2 described how very small amounts of ice can weather large rocks and break them into smaller pieces. Great ice sheets have changed the landscape over large areas. They erode land surfaces and deposit large quantities of sediments. In this section, you will learn how to identify evidence of erosion by glaciers.

By the end of this section you should be able to describe how glaciers are made and how they move; identify the range and location of glaciers, past and present; and infer erosion by glaciers from landscape features.

Activity 1: Ice-Carved Landscapes

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This activity is based on information contained on pages 332 and 333 of *Science Directions 7*. Read these pages and look at the drawings at the bottom of page 333. Try to understand how **glaciers** form and spread, and how they have changed the landscape over large areas.

Glacier: a large mass of ice formed from snow on high ground wherever winter snowfall exceeds summer melting It moves slowly down a mountain or along a valley.

Just as in studying rivers, scientists have developed a model to explain how glaciers form. Think back to your textbook reading. It mentions how pancake batter or muffin mix spreads out in a pan as you pour. In land areas at the extreme north and south of the world, near the poles, and in high mountain regions, it is so cold that the snow that falls never melts, even in summer. Each winter new snow falls on top of the snow that remains from the past summer. Each year fresh snow builds up on top of the older layers of snow. The weight of the snow as it builds up higher and higher packs the lower layers into ice. The ice gradually spreads out, similar to the pancake batter model mentioned.

Continental glacier: glacier that covers a large area of land, such as Greenland or Antarctica

Valley glacier: a glacier in a valley in a mountain region

To form glaciers low temperatures and the accumulation of snow are necessary. From your textbook reading you have also learned that there are different types of glaciers. You should know what **continental glaciers** and **valley glaciers** are and where they are located. Currently continental glaciers cover approximately ten percent of the world's total land area. Of this, about eighty-five percent is in Antarctica, ten percent in Greenland, and five percent in Iceland, central Asia, and the Arctic. Valley glaciers are found in high mountain ranges throughout the world, including Canada's Rocky Mountains. When ice reaches the top of a steeply sloping mountain valley, gravity causes the ice to move down the valley, just as gravity causes a river to flow down a slope.

Interpretations

1. Observations made during the last 100 years show that valley glaciers are getting smaller. What would have to change for them to start getting larger and moving farther out into valleys?

2. What is the same about valley glaciers and continental glaciers?

3. What is different about valley glaciers and continental glaciers?

____

____

____

4. Why are valley glaciers called *rivers of ice*?

____

____

____

5. Why is it hard to believe that glaciers are spreading across continents or flowing down valleys?

____

____

____

Check your answers with your learning facilitator.

Activity 2: Interpreting Glacier Movement

You may not believe that valley glaciers are moving down the mountainsides. You can spend a whole day watching a glacier and not see any movement. What you are more likely to notice is that the glacier is melting.

You have seen a photograph of the Athabasca Glacier on page 332 of your textbook when you did Activity 1. The Athabasca Glacier in Alberta has melted back so that the end of the glacier is almost 2 km farther back than it was in 1750. Even in 1896, the glacier was much farther down the valley than it is now. Then it blocked the entire valley where the highway from Lake Louise to Jasper now runs.

Scientists have shown that the glacier is moving down the valley, even as it melts back. To measure how fast the glacier is moving down the valley, markers were pounded into the ice at the centre of the glacier. In 1976, the centre of the glacier flowed forward 35 m, yet the end of the glacier retreated 3 m. So it seems that the end at the bottom is melting faster than the glacier is flowing down the valley. If you visit the Athabasca Glacier you will see where the end of the glacier used to be years ago.

Read Moving Forward and Melting Back on page 334 of *Science Directions 7*. Then carefully examine the illustration on the bottom of pages 334 and 335 to answer the following questions.

Snout: the front edge of a glacier

Stationary glacier: a glacier with the snout staying in the same position

1. a. In which part of the illustration was the **snout** of the glacier **stationary**?

   b. What weather conditions must be present for a glacier to be stationary?

Advancing glacier: a glacier with the snout moving forwards

2. a. In which part of the illustration was the front of the glacier **advancing**?

   b. What weather conditions are likely present for a glacier to be advancing?

Retreating glacier: a glacier with the snout moving backwards

3. a. In which part of the illustration was the front of the glacier **retreating**?

b. What weather conditions are likely present for a glacier to be retreating?

Check your answers with your learning facilitator.

Activity 3: Evidence of Erosion by Glaciers

Earlier you have studied how some landscape features are caused by either water or wind erosion. However, there are landscape features which cannot easily be explained by the action of water or the action of wind. Why are there large boulders present in relatively flat areas? Why are there deposits of pebbles and gravel of different rock types than those in the surrounding area? Could these boulders and pebbles have been carried by glaciers, then dropped as the glaciers melted?

Read The Puzzle of the Boulders on page 335 and Ice Across the Land on page 336 of *Science Directions 7*. Pay attention to how geologists such as Johann van Charpentier and Louis Agassiz went about obtaining evidence to suggest that sheets of moving ice were responsible for some of the landscape features that could not be explained by either wind or water erosion.

The inference that glaciers once covered land many kilometres away from their present site could not be considered reasonable until many supporting observations were gathered as evidence. Do you believe that glaciers once covered almost all of Alberta? How would you convince someone else?

Charpentier and Agassiz compared features they had observed in the areas of valley glaciers with features a long way from the valley glaciers. They accumulated evidence which indicated that sheets of ice had once covered large areas of Europe over a period of many years. Other geologists have since found similar evidence in North America. Sheets of ice have covered large areas of Canada and the northern United States on several occasions in the past. The periods when ice sheets covered large areas of Europe and North America are known as Ice Ages.

There are still many glaciers in mountain ranges in western Canada. A close look at the effects these glaciers have had on the landscape could help in interpreting the evidence for or against past glaciation.

Erratic: a large rock that has been carried by a glacier to a location where the rock types are different

Striations: scratches in rock made by a glacier as it moved across the rock

The puzzle of the boulders you read about earlier in this activity is the first piece of evidence that glaciers once extended much farther than they do today. These larger boulders are called **erratics**.

Now examine the photographs along the bottom of pages 338 and 339 of the textbook. The center photograph shows **striations**. Scientists have found many examples of long parallel scratches on rocks. The most puzzling thing about these scratches is that they all run in the same direction, even though they may be on rocks far apart.

To explain striations, remember that glaciers flow. Like rivers, glaciers carry loose rocks and stones along with them as they move. Some of these have fallen onto the glacier from the surrounding mountains. These rocks ride along the top of the glacier and do not become rounded like the rocks carried in a river. Others are dragged from the sides and floor of the valley. They are moved along the valley by the bottom layer of ice in the glacier. As this bottom layer moves along with its load of rock fragments, the soil is pushed aside and the glacier scratches the rock beneath it. Since the glacier moves in only one direction, the scratches will all be in the same direction and will all be parallel. Striations are another piece of evidence that glaciers once extended much farther than they do today.

Glaciers and rivers both form valleys as they erode rock. You learned in Section 3 how rivers form V-shaped valleys as they erode the bottom of the valley, and the sides of the riverbank cave in. A glacier erodes rock on the bottom of the valley, but also on the sides. In doing this, a U-shaped valley is formed, like the one in the photograph at the bottom of page 339 in your textbook. U-shaped valleys are evidence that glaciers once filled the valley. The large U-shaped valley that the Bow River now runs along between Banff and Calgary is an example.

Moraine: rock or other materials that have been deposited by a glacier

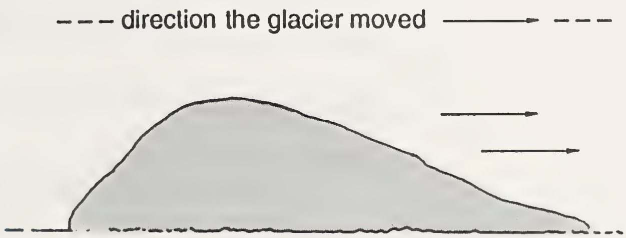
As ice pushes along the walls of a valley, ridges form along the sides of the glacier. These ridges are formed from the build up of rocks. Like other glacial sediments, these rocks are not smooth like rocks in a river, and are unsorted, or mixed together with sand and gravel. These ridges run in the same direction that the glacier moved. The photograph on page 337 of your textbook shows a side, or lateral, **moraine** deposited by a melting glacier.

Other rocks that have fallen onto a glacier are moved to the snout. As the ice melts, these rocks pile up, forming an end moraine. The photograph that straddles pages 336 and 337 in your textbook shows how an end moraine is formed.

Side moraines are evidence of the direction a glacier flowed. End moraines show where the glacier was stationary for a period of time.

Drumlin: long, oval-shaped hill found in areas that were once covered by glaciers

Sometimes sediments very similar to those in a moraine are found in hills with an unusual shape. The photograph on the left side of page 338 of the textbook shows a **drumlin**. Drumlins point in the same direction as striations in the same valleys. Drumlins are made of unsorted sediments ranging from silt to large rocks. The rocks are rough with sharp edges, so they are most likely not deposited by a river. Scientists explain that they were probably formed when a glacier ran over materials in a moraine left by an earlier glacier. As the glacier ran up and over the moraine, the sediments were forced into a line pointing in the direction the glacier was moving.



Shape of Drumlin

Kettle lake: a hollow formed in the surface of the land where a large block of buried ice melted The hollow later filled with water to form a lake.

Another piece of evidence that glaciers once extended much farther than they do today are **kettle lakes**. The ground around kettle lakes is made up of unsorted, angular-shaped rocks much like in a moraine. The explanation that connects kettle lakes to glaciers is that a large chunk of ice from a melting glacier was surrounded by rocks and sediments from the glacier. As the chunk of ice slowly melted, a hole was formed. This hole filled with water to make a kettle lake. The photograph near the bottom of page 339 in the textbook shows a kettle lake.

Using erratics, striations, U-shaped valleys, moraines, drumlins, and kettle lakes as evidence, scientists have demonstrated that at least four ice sheets advanced and then retreated across North America and Europe within the last million years. During these Ice Ages it was much colder than it is today. The retreat of the last ice sheet was about 11 000 years ago. We are now in a warm period. Scientists do not know if, or when, another Ice Age might come. Scientists are continuing to study the evidence for and against future Ice Ages.

7 Science Directions

For additional information on how you can infer that glaciers were once present in a particular region by looking at certain landscape features, read pages 337 to 341 of the textbook.

It is difficult to simulate all the effects of a glacier, but you can demonstrate the formation of striations and kettle lakes by using ice cubes.

Materials You Need

- sand
- gravel
- several ice cubes
- several ice cubes made from water mixed with gravel
- several ice cubes made from water mixed with coarse sand
- plastic bucket
- piece of cardboard

Steps to Follow

Step 1: Pour about 5 cm of sand into the bucket.

Step 2: Bury an ice cube in the sand and push another part-way into the sand.

Step 3: Leave the ice cubes until they have completely melted. Once the ice has completely melted, record your observations in the following Observations box.

Note: Go on to Step 4 while waiting for the ice cubes to melt.

Observations

Note: You may use diagrams as part of your description of what you observe.

Steps to Follow (continued)

Step 4: While you are waiting for the ice cubes to melt, pull an ice cube across the piece of cardboard. In the Observations boxes which follow, record any effects on both the cardboard and the surface of the ice.

Step 5: Pull an ice cube with gravel frozen in it across the piece of cardboard. Record the effects on both the cardboard and the ice surface.

Step 6: Repeat using the ice cube with sand frozen in it.

Observations (continued)

Clear Ice Cube

Ice Cube with Sand Frozen in It

Ice Cube with Gravel Frozen in It

Questions to Answer

1. Which parts of this activity simulated making striations?

____

2. Which parts of this activity simulated making kettle lakes?

____

3. a. Which pieces of evidence show the direction that a glacier was moving before it melted?

____

____

   b. How do they show the direction?

____

____

4. Describe one way that river erosion is similar to erosion by glaciers.

____

____

____

5. Describe one way that river erosion is different from erosion by glaciers.

____

____

____

6. Consider what you have learned about how glaciers form and move. Explain how large rocks can be moved many kilometres to areas where there are no glaciers?

____

____

____

Check your answers with your learning facilitator.

Follow-up Activities

If you had difficulties understanding the concepts in the activities, it is recommended that you do the Extra Help. If you have a clear understanding of the concepts, it is recommended that you do the Enrichment.

Extra Help

In Alberta, the climate is such that during winter snow falls, but the summer is warm enough to melt all of the snow. Near the top of some mountains, it is not warm enough to melt all the snow that falls. One place that this happens is the top of the mountains behind Lake Louise. When more snow falls during the winter than can melt during the summer, the snow builds up. This is called accumulation.

As the snow piles up, it forms ice near the bottom. If enough ice builds up, it starts to move, very slowly, down the mountain. This is called a glacier.

The weather is warmer near the bottom of the mountain, so the glacier melts as it moves down the mountain.

If there is more cold weather than warm weather for several years, or if there is very heavy snowfall, glaciers will move farther down a valley before melting. The glacier is said to advance when this happens.

If there is more warm weather than cold weather for several years, or years with light snowfall, glaciers will not move as far down a valley before melting. The snout of the glacier appears to move up the mountain. The glacier is said to be retreating.

If the amount of warm weather and cold weather stays the same for several years, the snout of the glacier stays at the same spot. The glacier is called stationary. You should remember that a "stationary" glacier is always moving down the mountain; it is just melting at the same rate that it is moving.

1. How can an advancing glacier carry rocks down the valley?

____

____

____

2. How can a stationary glacier carry rocks down the valley?

____

____

____

3. What force makes a glacier move down a valley?

____

To simulate how a continental glacier flows outward, form some modelling clay into a block that is about 5 cm on every side. Place the block on a sheet of paper and trace the outline of the block. Add some weight to the top of the modelling clay block (a small book will work). Leave the clay for 15 minutes. Trace the outline around the clay again. Peel the clay off the paper and compare the outlines.

4. Describe how the modelling clay changed.

____

____

____

5. What would cause a continental glacier to quit spreading outward?

____

____

____

6. Following is a list of landscape features mentioned in this module:

deltas	rounded pebbles
drumlins	rough-edged pebbles
erratics	sand dunes
kettle lakes	V-shaped valleys
moraines	wide U-shaped valleys
oxbow lakes	

List the six features that would indicate that a glacier has been present.

- ______________________ • ______________________
- ______________________ • ______________________
- ______________________ • ______________________

Discuss your answers with your learning facilitator.

Enrichment

You may choose to do only Part A or Part B,
but you may do both Part A and Part B, if you wish.

Part A involves doing research about some landscape features caused by glaciers.

Part B involves doing research on a part of Alberta that was not covered by glaciers during the last Ice Age.

Part A: Researching Glacial Features

Two features caused by a glacier are a cirque and an esker. Do some research; then describe what each looks like and how each was made by a glacier. Use the space provided.

Check your answers with your learning facilitator.

Part B: Researching a Part of Alberta Not Covered by Glaciers During the Last Ice Age

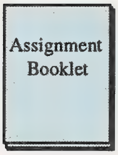
The tops of the Cypress Hills in Alberta and Saskatchewan were not completely covered with ice during the last Ice Age. Some of the plant and animal species living today in the Cypress Hills are different from those in the surrounding lowlands. How can you explain these differences? First, propose your own explanation based on what you have learned in this section. Then try to find one in a library. A book that describes the geography of Alberta or one that describes the geology of Alberta may be a good source. Was your explanation similar to the one you found?

Check your answers with your learning facilitator.

Conclusion

Glaciers have had a major influence in shaping the Earth's surface. They have shaped mountains by gouging out valleys and spreading the eroded materials across the continent. Scientists have developed models to explain how glaciers advance and retreat. These models have helped explain features such as erratics, kettle lakes, and moraines.

The influence of glaciers is a direct result of the climate on Earth, which seems to change over long periods of time, causing the coming and the going of continent-wide glaciers.



ASSIGNMENT

Turn to your Assignment Booklet and do the assignment for Section 5.

Note: After you have completed the assignment for Section 5, read the Module Summary which follows.

MODULE SUMMARY

This module began with the idea that the Earth's surface is being changed. Some of these changes occur very quickly. Most changes occur so slowly that you will notice very little change during your lifetime.

You should now be able to explain the differences between mechanical and chemical weathering. You should also be able to describe examples of biological weathering.

You should be able to explain how moving water, wind, and glaciers are at work eroding solid rock and creating different landforms.

These forces are continually wearing down the Earth's surface. Next year you will learn about some of the forces that are building up the Earth's surface.

Appendix

Glossary

Acid rain • rain with a very high acid content resulting from air pollution

Advancing glacier • a glacier with the snout moving forwards

Avalanche • a large mass of snow and ice, or of dirt and rocks, sliding or falling down a mountainside

Biological weathering • the weathering caused at least in part by the action of living things

Boulders • very large rocks

Chemical weathering • the weathering or breaking down of rocks by the action of chemicals, resulting in different materials being formed

Clay • finely divided particles of rock with grain sizes of less than one five-hundredth of a millimetre

Continental glacier • glacier that covers a large area of land, such as Greenland or Antarctica

Delta • land that has formed at the mouth of a river from sediments carried by the river

Deposition • the settling of sediments carried by wind or water

Drumlin • long, oval-shaped hill found in areas that were once covered by glaciers

Erosion • the wearing away and movement of rock materials from place to place

Erratic • a large rock that has been carried by a glacier to a location where the rock types are different

Geologist • a scientist who studies the Earth

Glacier • a large mass of ice formed from snow on high ground wherever winter snowfall exceeds summer melting
It moves slowly down a mountain or along a valley.

Gravel • rock fragments of various sizes, larger than grains of sand

Groundwater	• water accumulated beneath the Earth's surface in the pores of rocks, spaces, cracks, and so on
Hoodoo	• a column of soft rock with a cap of harder rock
Ice wedging	• water getting into cracks in rocks, freezing in the cracks, and breaking the rocks apart
Inference	• an explanation based on observations; a conclusion
Kettle lake	• a hollow formed in the surface of the land where a large block of buried ice melted The hollow later filled with water to form a lake.
Landforms	• the natural physical features of the land
Leeward	• the side that is sheltered from the wind
Meander	• a type of curve in the bed of a river or stream
Mechanical weathering	• the weathering caused by changes in temperature and by water freezing in cracks
Model	• a diagram, description, or a miniature representation of something
Moraine	• rock or other materials that have been deposited by a glacier
Observation	• information gathered by using the five senses
Pebbles	• rounded stones, usually 0.5 cm to 2 cm in diameter
Porosity	• the amount of space between particles The porosity of soil means how much space there is between the particles making up the soil.
Retreating glacier	• a glacier where the snout is moving backwards
Runoff	• rainwater that runs across the surface of the ground instead of sinking into it
Sand	• particles of rock, usually granular and gritty (larger than clay but smaller than pebbles or gravel)

Sediment	• earth, stones, sand, and so on, deposited by water, wind, or ice
Silt	• finely divided soil particles or sediments (finer than sand but not as fine as clay)
Snout	• the front edge of a glacier
Stalactite	• a spike-shaped formation of calcium carbonate hanging down from the roof of a cave
Stalagmite	• a spike-shaped formation of calcium carbonate extending upwards from the floor of a cave
Stationary glacier	• a glacier with the snout staying in the same position
Strata	• parallel layers of rock
Striations	• scratches in rock, made by a glacier as it moved across the rock
Surface water	• the water that forms on the surface of the ground in areas where the water table reaches ground level Streams, rivers, lakes, and sloughs are examples of surface water.
Talus	• an accumulation of irregular shaped rocks at the base of a cliff or steep mountain
Tributaries	• streams that flow into rivers
Valley glacier	• a glacier in a valley in a mountain region
Water table	• the highest level that water sinks to in the ground
Weathering	• the natural breaking down of solid materials into smaller pieces, and the changes in color that take place on solid materials
Windward	• the side from which the wind is coming

Science 7
9SC07P16
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